XI. Notes on some cases of Seasonal Dimorphism in Butterflies, with an account of Experiments by Mr. G. A. K. Marshall, F.Z.S. By Frederick A. Dixey, M.A., M.D., F.E.S., Fellow of Wadham College, Oxford.

[Read March 19th, 1902.]

Plate IV.

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1. Seasonal Dimorphism in *Catopsilia pomona*, Fabr.

I have long been of opinion, from the examination of many hundred specimens, that no line of specific demarcation can be drawn between *Catopsilia pomona*, Fabr., and *C. crocale*, Cram. This conclusion was based mainly on the fact that, distinct in appearance as typical examples of the two forms undoubtedly are, it is easy to arrange a series of examples showing every possible gradation between the two. The relation between *C. pomona* and *C. crocale* so much resembles that between forms which there is reason for regarding as cases of seasonal dimorphism, that I was led to suspect that the dimorphism of *C. pomona-crocale* might also have a seasonal significance. In 1898 I mentioned my suspicion to Mr. Trimen, showing to him at the same time a good series, including many transitional forms, of *C. pomona*, which had been captured near Brisbane in 1897 by T. Batchelor, and presented to the Hope collection by Mr. G. C. Griffiths. This series was noticed by Mr. Trimen in his Presidential Address to the Entomological Society of London, delivered on January 18, 1899, and was considered by him as "lending some probability to the view

that *C. crocale* and *C. pomona* (including *C. catilla*) will prove to be seasonal forms of one species." * Direct evidence on the point was, however, lacking; and I therefore welcomed a statement made later by Batchelor in a letter from Brisbane, and kindly communicated to me by Professor Poulton, that *C. crocale* and *C. pomona* were one species, "*crocale* being the summer brood and *pomona* the autumn one." It does not appear that any observer has as yet actually bred one form from the other, so that it cannot even now be said that their specific identity is proved with absolute certainty. Nevertheless, the opinion of a collector who has taken large numbers of both forms is of weight, and may safely be held to indicate a strong probability that, at all events in part of their range, *C. pomona*, Fabr. and *C. crocale*, Cram. are seasonal phases of the same species.

It is, however, evident that the case with regard to *C. pomona* is not quite a simple one. In the autumn of 1900, a series of eighteen specimens of *Catopsilia* was received by the Hope Professor at Oxford from the late Mr. L. de Nicéville, who stated that they were all caught nearly at the same time in the Kangra Valley, Western Himalayas, by Mr. G. C. Dudgeon. Of these eighteen, sixteen were taken on August 11, and the remaining two on August 13, 1900. Two of the captures on August 11 were *Catopsilia pyranthe*, Linn.; and of the remainder, eight were *C. crocale*, Cram., and six were *C. pomona*, Fabr. Those caught on August 13 were *C. crocale* ♂ and *C. pomona* ♀ taken in copulâ. In two private letters to the Hope Professor, Mr. de Nicéville appeals to this series of specimens in support of the view that *C. pomona* † and *C. crocale* constitute one

* Proc. Ent. Soc. Lond., 1898, p. lxxvi. It is hardly necessary to recall the fact that this address of Mr. Trimen's contains an excellent account of nearly all the experiments and observations that had been made on the subject of seasonal dimorphism in butterflies up to the time of its delivery.

† De Nicéville calls it *C. catilla*, Cram.; but the latter name, under which Cramer figures the form with brownish-crimson patches on the under-surface (*see* Cramer, Pap. Exot., III. t. 229, D, E), is later than that of Fabricius. Fabricius's type still exists in the Banksian cabinet, where I have examined it in concert with Dr. A. G. Butler. The six specimens of *C. pomona* caught on August 11 include two *C. catilla*, Cram. The British Museum contains six specimens of *C. crocale* and seven of *C. pomona* caught by Mr.

variable species, the variation not being due to seasonal causes. This view was published by de Nicéville in 1894, and was reiterated by him on several subsequent occasions.* There can be no doubt that de Nicéville's opinion receives support from the present series of specimens. The fact of *C. crocale* ♂ pairing with *C. pomona* ♀ tends to show their specific identity, while the simultaneous occurrence of the two forms in presumably equal numbers seems adverse to the supposition that the dimorphism of this species has a seasonal significance.

With regard to the first point, that of specific identity, I think there can now be no reasonable doubt that the case is made out. I have already mentioned my own conviction on the matter, which was arrived at independently, and on different grounds. Batchelor's observations here coincide with de Nicéville's; and it may be added that Piepers,† who has bred the species in large numbers, is strongly of the same opinion. On the other hand, Dr. L. Martin, writing of the butterflies of Sumatra (Journ. Asiat. Soc. of Bengal, LXIV, ii, p. 490, 1895), considers *C. crocale* and *C. catilla* (*pomona*) distinct, on the following grounds:—*C. crocale*, the far commoner form, occurs on roads, near houses and gardens, and is never found in the forest. *C. catilla* is found only in the forest. The antennæ of *C. crocale* are black in both sexes, those of *C. catilla* are red. The underside of the males in *C. crocale* is unspotted, and the tuft of hair on the inner margin is whitish. In *C. catilla* the males, like the females, have reddish spots on the underside of both wings, and the tuft of hair is

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Dudgeon on the same occasion (August 12) as those mentioned above. They are stated to have formed part of a migratory flight which lasted all day.

* Gazetteer of Sikkim, p. 166, 1894; Journ. Asiat. Soc. Bengal, LXIV, ii, p. 490, 1895; Journ. Bombay Nat. Hist. Soc., xi, p. 586, 1898; Journ. Asiat. Soc. Bengal, LXVIII, ii, p. 211, 1899. The first two of these are cited by Mr. Trimen, *loc. cit.*, p. lxxvi, note.

† "Die Farbenevolution bei den Pieriden," Tijdschr. der Nederlandsche Dierk. Vereenig.; (2) Deel V, p. 119, 1898. Piepers gives *thaumoma*, Reak., as a synonym; the latter, however (from Madagascar), is unquestionably distinct. "*Pomona*, Cram." (*ibid.*) is a slip; the name was bestowed by Fabricius. Piepers's view was first published in 1891—"Observations sur des vols de Lépidoptères"—Natuurkundig Tijdschrift voor Ned.-Indië, Dl. L, 1891, pp. 205, 222. In the same periodical, Dl. LVII, 1898, he repeats it, but speaks, rather curiously, of "*Gnoma*, Feld.," as a form of "*Catopsilia pomona*, Cram." (*loc. cit.*, p. 111).

distinctly yellow. The females of both forms are variable, but the range of variation is distinct in the two. De Nicéville, however, rightly remarks that "the distinctive characters on which Dr. Martin relies are all quite inconstant, and entirely break down" when large numbers of both forms are examined. It may be added that the difference of habit alleged to exist between *C. crocale* and *C. pomona* is no disproof of specific identity, inasmuch as a similar difference, witnessed to by both Trimen* and Marshall,† obtains between *Precis sesamus*, Trim. and the southern representation of *P. octavia*, Cram. (called by Marshall *P. octavia-natalensis*). The form *natalensis*, according to Marshall, frequents high, open spots; *sesamus* is shade-loving, though it occasionally flies with *natalensis*, especially at the change of seasons. *Sesamus* is more wary than *natalensis;* it is more often found in gardens, and occasionally enters human habitations. It also contrasts with *natalensis* in being at times gregarious. But in spite of these well-marked divergencies of habit, the two forms, as is well known, have been absolutely proved to be seasonal phases of the same species. Hence, in the case of *C. pomona* and *C. crocale*, Dr. Martin's objection on the score of habit cannot be held any more conclusive than that founded on the difference in aspect.

With regard to the second point, that of the seasonal relations of the two forms, it seems that the utmost we can at present allege is that in part, at all events, of its range the dimorphism of *C. pomona* is associated with the change of season. That this is not the case everywhere is evident from de Nicéville's observation, as quoted by Trimen,‡ that "the innumerable varieties which are found in both sexes occur at all times;" and, more particularly, from the statement that "both true *C. crocale* and the dimorphic form, *C. catilla*, Cram. occur commonly in Mussoorie from July to October, and in Dehra Dun throughout the warmer months of the year." § On the other hand, we have Batchelor's categorical assertion from

* South-African Butterflies, vol. I, 1887, pp. 230, 233.

† Ann. Mag. Nat. Hist., 1898, vol. II, pp. 33, 34.

‡ Proc. Ent. Soc. Lond., 1898, p. lxxvi.

§ Mackinnon and de Nicéville, Journal of Bombay Nat. Hist. Soc., vol. XI, 1898, p. 586. Piepers also denies absolutely that the dimorphism of *C. pomona* is seasonal ("Notes from the Leyden Museum," vol. XXII, 1899, note 1, p. 13, *ibique cit.*).

Brisbane, given above; while the fact recorded by Dr. Martin (*loc. cit.*) that among many hundreds of both sexes of *C. crocale*, all presumably belonging to one emergence, taken by him near Bindjei, there was not a single *C. catilla* (*pomona*), may possibly have a similar significance.*

It is not a little remarkable that although there are forty-three specimens of *C. pomona* and *C. crocale* in the Hope collection duly labelled with locality and date, they cannot be said to throw much light on the question of seasonal dimorphism. What is wanted is a long series of observations carefully carried on in one locality, and accompanied, if possible, by breeding experiments.

If, as is probable, it should eventually be shown beyond doubt that the different forms of *C. pomona*, though related to the seasons in some part of its range, occur indifferently at all times in others, the case would by no means stand alone. I propose in the next place to notice very briefly several statements that have been made by different authorities with regard to other species, which statements tend to show that in many cases where the existence of seasonal modification has been reasonably presumed, or even actually demonstrated, the seasonal relation is far from being rigidly fixed in all parts of the area of distribution.

2. Seasonal Dimorphism in *Catopsilia pyranthe*, Linn.

The first instance that may be taken is that of *Catopsilia pyranthe*, Linn. This butterfly grades imperceptibly into *C. gnoma*, Fabr. just as *C. crocale* does into *C. pomona*. Here again, in the absence of breeding experiments, the absolute proof of specific identity is still lacking; but de Nicéville had no doubt, from his own observations, that the two forms represent a single species. In this case he is able to assign a seasonal value to the two forms,—*C. pyranthe* being in his opinion the wet-season, and *C. gnoma* the dry-season phase of the species. But the point of special interest, in view of the irregularity that appears to obtain in the seasonal relations of *C. crocale* and *C. pomona*,

* It should, however, be noted that "N.-E. Sumatra does not possess a well-marked dry and wet season, such as is found over most of the continent of India, there being no month in the year when it does not rain." Journ. Asiat. Soc. Bengal, LXIV, 1895, pt. ii, p. 362. See below, p. 196.

is the fact that, as recorded by de Nicéville himself, the different forms of *C. pyranthe*, though corresponding to the seasons in some parts of its range, are independent of them in others. Thus, in speaking of this species under the name of *C. chryseis*, Drury, he notes that "it is not seasonally dimorphic in Sumatra as it is in India." * Again, he remarks under *C. pyranthe*, "Moore in the 'Lepidoptera of Ceylon' gives four forms of this species as separate species; *C. gnoma*, Fabr., *C. ilea*, Fabr., *C. chryseis*, Drury, as well as typical *C. pyranthe*. Manders notes that as far as his observations go these four forms are not dependent on season, but appear indiscriminately nearly throughout the year, those flying in the dry season from February to April being a little smaller than those found during the rest of the year." † On the other hand he says, "True *C. pyranthe* is not very common in Mussoorie in the rains; the dry-season form, *C. gnoma*, Fabricius, even less so. In the Dun both forms are common in their respective seasons." ‡

If then we are to trust the observations that have been cited, we are led to the conclusion that in these *Catopsilias*, viz., *C. pomona* and *C. pyranthe*, we have to deal with two polymorphic species, each of which has no doubt several geographical forms, and each of which shows, in most localities, a special tendency to cleavage into two well-contrasted types. These latter phases in each case are in some parts of the range of the species dependent on seasonal changes; in other parts, however, they show no such connection.

We may now pass on to the consideration of similar irregularities as shown in other groups.

3. Irregularities of Seasonal Dimorphism in various Genera.

It has been recorded by most of those who have experimented on the subject, that there are individual differences in the reaction of members of the same brood to what appear to be identical conditions of the environment. A conspicuous instance of this is the well-known

* Journ. Asiat. Soc. Beng., LXIV, 1895, ii, p. 490.
† *Ibid.*, LXVIII, 1899, ii, p. 211.
‡ Journ. Bombay Nat. Hist. Soc., XI, 1898, p. 586.

experience of Mr. Marshall, who in April 1898 bred a specimen of *Precis sesamus* and another of *P. octavia-natalensis* from two eggs, laid on the same day by the same mother, and reared under precisely similar conditions.* Dr. Butler has also put it on record that Captain Nurse bred *Teracolus yerburii*, Swinh., and *T. nouna*, Luc.,† from a batch of similar larvæ, the perfect insects presumably emerging at the same season. Many cases have been observed where, although each of the two forms of a species is on the whole confined to its own time of year, there is yet a considerable amount of overlapping at the change of seasons; this overlapping showing itself both by the simultaneous occurrence of freshly-emerged specimens of both phases, and also by the appearance of a more or less complete series of "intermediates." A good instance of the simultaneous occurrence, in the field, of different phases believed on strong grounds to be seasonal, is afforded by the capture of all three forms ("wet," "dry," and "intermediate") of *Precis sesamus* by Mr. Crawshay at Nairobi within little more than a week during the month of April.‡ Many records of this kind are in existence; and are often, no doubt, to be ranked as examples of the seasonal overlapping that has just been mentioned.

It is however evident that there are numerous cases of simultaneous occurrence which cannot be brought under this head. Besides the definite statements of de Nicéville with regard to two species of *Catopsilia*, we have now a considerable bulk of evidence, with regard to many species, of the appearance side-by-side, at all times of year, of forms closely analogous with what are now well established as seasonal phases. Thus, again according to de Nicéville, the ocellated and non-ocellated forms of *Melanitis leda*, Linn., which he has shown to be related in India to the wet and dry seasons respectively, both occur in North-East Sumatra all the year round. In Java it has been

* Ann. Mag. Nat. Hist., 1898, vol. ii, p. 30.

† More accurately, perhaps, *T. evagore*, Klug. *T. nouna* is the dry-season phase of the African form *T. daira*, Klug. Capt. Nurse's larvæ were found at Shaik Othman, and no doubt belonged to the Arabian form, of which *T. yerburii*, Swinh., is the wet, and *T. evagore*, Klug, the dry-season phase. This is pointed out by Butler in Ann. Mag. Nat. Hist., 1897, vol. ii, p. 460. The original record is in Proc. Zool. Soc., 1896, p. 247.

‡ Proc. Zool. Soc., 1900, p. 916.

noted by Piepers * that the non-ocellated form, though on the whole belonging chiefly to the dry season, is also to be met with during the rains. It is true, as Piepers says, that in Java, as in the Malayan Islands generally, the distinction between dry and wet season is not so sharp as on the Indian mainland; so that a certain amount of intermingling of the two forms might perhaps have been antecedently expected. It does not appear, however, that all dimorphic species are affected by these or the like conditions in the same way. De Nicéville points out, in a passage quoted by Trimen, that with this exception of *Melanitis leda* there are no dry-season forms in North-east Sumatra; and Doherty mentions analogous facts in reference to localities with a generally moist climate, like Ceylon and Singapore, and also, *mutatis mutandis*, to dry countries like Sind.† The prevalence of wet-season forms in the equatorial forest region of West Africa is another phenomenon of the same kind. Instances such as these show that a generally damp country may be characterized by a greater abundance of "wet-season" forms, and *vice versâ*. But these cases of the prevalence of "dry" or "wet-season" forms respectively, according to the general climatic conditions of a given locality, are, as we have just seen, accompanied by others which seem to prove that in certain districts, especially perhaps dry ones, the phases that are usually associated with the seasons occur indiscriminately at all times of the year.

Many such instances are recapitulated by Butler in his late revisions of the genera *Teracolus* and *Terias*. *Teracolus eupompe*, Klug, for example, has a wet, an intermediate and a dry phase. "The two latter undoubtedly fly together, and in Aden it is tolerably certain that all the phases emerge at the same time as mere variations." ‡ With regard to *T. halimede*, Klug, Butler observes, "*T. æaste* represents the wet-season phase, *T. halimede* the

* "Die Farbenevolution bei den Pieriden," Tijdschr. der Nederl. Dierk. Vereenig; (2) Deel V, 1898, pp. 179–185, etc. The value of the theoretical considerations based by Piepers on the facts that he has evidently observed with much care, appears to me to be greatly diminished by his refusal to admit the influence of selective adaptation, even as a provisional hypothesis.

† Proc. Ent. Soc. London, 1898, p. lxviii. Compare Watson; Journ. Bombay Nat. Hist. Soc., 1894, vol. viii, p. 489, etc.

‡ Ann. Mag. Nat. Hist., 1897, vol. ii, p. 497.

intermediate, and *T. cœlestis* the dry-season phase of the species; but they are none of them confined to seasons, but occur (as is the case with other species in very arid countries) as mere coexistent variations." * Of *T. protomedia*, Klug, he remarks, "At Aden all three [seasonal] types occur together as mere variations." † Other species of *Teracolus* of which similar statements are made are *T. protractus*, Butl., *T. phisadia*, Godt., *T. puellaris*, Butl., *T. vestalis*, Butl., *T. evagore*, Klug, and *T. pleione*, Klug. With regard to *Terias* Butler also notes that, "as in *Teracolus*, those countries which have no wet season nevertheless produce the three phases of a species as coexistent varieties." ‡ There is reason to think that in the New World, at any rate, there may occur a similar intermingling of forms which is not confined to "countries having no wet season." Thus, Messrs. Godman and Salvin write as follows: "Many of these forms [of *Terias*] are said to be due to the season of the year at which they appear, wet-season and dry-season broods having each their peculiar characteristics. These observations have been made chiefly in the east. In our country we have not noticed any phenomenon of this kind." § Mr. G. C. Champion again, if my memory does not deceive me, in the discussion that followed the exhibition of certain specimens of *Callidryas* referred to by Mr. Trimen (*loc. cit.*), many of which were collected by himself, stated that according to his experience of these butterflies, the varying forms of the same species from the same locality had no definite relation to the seasons. Colonel Swinhoe, besides recording the fact that he has taken all the seasonal forms of certain eastern *Teracoli* flying simultaneously at Karachi, has also averred that he has captured *Byblia simplex*, Butl., the supposed dry-season form in India of *B. ilithyia*, Drury, practically all the year round. Some doubt has been thrown by de Nicéville and by Marshall on the latter observation; the

* Ann. Mag. Nat. Hist., 1897, vol. ii, p. 502. The dates of Col. Yerbury's captures at Aden clearly prove the simultaneous occurrence of different "seasonal" forms, but they do not seem incompatible with a certain amount of correspondence on the part of these phases with the time of year. See, *e.g.*, the dates given for *Teracolus cœlestis* and *T. acaste*; Proc. Zool. Soc., 1884, pp. 489, 490.

† Ann. Mag. Nat. Hist., 1897, vol. ii, p. 507.

‡ *Ibid.*, 1898, vol. i, p. 57.

§ Biologia Centrali-Americana. Rhopal. ii, p. 154.

former, however, says Butler, is a fact that can be proved from the data on the Museum specimens.*

Statements of this kind, the list of which could be largely extended, go far to show that the case of *Catopsilia pomona* and *C. crocale* is by no means an isolated one, and that just as there are regions in which more than one geographical form of a widely-ranging species may be found flying together,† so there are districts of a greater or smaller extent where diverse forms of a species, confined for part of its range to definite seasons, may all occur simultaneously. No doubt the data are as yet insufficient for a complete explanation of these phenomena. It seems, however, clear that the forms or phases which are usually called "seasonal" may occur under many diverse conditions and in many different proportions. It appears further that they do not fall into a regular system of succession, except in the presence of regular alternations of season, and not always then. I still venture to think that a probable view concerning many of them is that briefly expressed by me some years ago in "Nature" (Vol. lx ; 1899, p. 98), viz., that polymorphism, however it may have arisen, is capable of being brought more or less into relation with locality and season under the influence of natural selection. On the other hand, it is conceivable that in some cases at all events the forms in question may have first arisen as adaptations to the seasonal changes, and afterwards, in consequence of extending their range, or of some other alteration of conditions, may have partly or entirely lost

* Ann. Mag. Nat. Hist., 1897, ii, p. 386 ; *Ibid.*, 1896, ii, p. 335. The following instances may be added from specimens with data in the Hope collection :—(1) Australian form of *Terias hecabe*, Linn. (*T. sulphurata*, Butl.) ; the dry, wet, and intermediate seasonal forms, all taken by Mr. J. J. Walker, R.N., on June 19, 1890, at Port Darwin, North Australia. (2) *Teracolus phlegyas*, Butl. (*T. difficilis*, E. M. Sharpe) ; a wet-season male taken paired with a dry-season female, both in good order, by Mr. G. A. K. Marshall, May 3, 1899, at Salisbury, Mashonaland. (3) *Teracolus restalis*, Butl. ; the wet and dry-season forms both taken at Karachi on May 10, 1888, by Mr. W. D. Cumming. (4) *Belenois severina*, Cram. ; wet and dry-season forms both taken on Feb. 13, 1897, at Karkloof, Natal ; a wet-season male paired with a wet-season female, and another wet-season male with a dry-season female on Feb. 24, 1897, at Malvern, Natal. All these by Mr. G. A. K. Marshall.

† *E. g.* the various forms of *L. chrysippus*, Linn., which are all found together at Aden. See Butler in Proc. Zool. Soc., 1884, pp. 478–481 ; and Col. Yerbury in Journ. Bombay Nat. Hist. Soc., 1892, p. 209.

their correspondence therewith. These are questions that must, I think, for the present remain unanswered; though whatever the solution may be, there seems no need to anticipate that it will weaken the case for selective adaptation.

4. Experiments and Observations in Seasonal Dimorphism conducted by Mr. G. A. K. Marshall, F.Z.S., in the years 1896—1901.

In the "Annals and Magazine of Natural History," 1901, ii, p. 403, Mr. Marshall writes as follows:—"Two years ago I made a few experiments in applying moist heat to the pupæ of several species of *Teracolus*. Unfortunately all my notes on the subject have been lost, but, so far as I can recollect, the results were almost entirely negative, which I then attributed to insufficient heat. The resulting specimens were, however, sent to the Oxford University Museum with full data." There are also in the Hope collection several other specimens, collected by Mr. Marshall in 1896 and following years, which are of considerable interest in their bearing on the subject of Seasonal Dimorphism. By the kindness of the Hope Professor, I am permitted to give Mr. Marshall's own comments on both series of specimens. These are contained in private letters to Professor Poulton, and have not hitherto been published. I propose to arrange the notes in chronological sequence; but it will be seen that the experiments fall into two main groups, which are more or less intermingled in order of time. The first group of experiments includes cases where one form of a species was reared under normal conditions from eggs laid by another form of the same species. In the second group of experiments, the pupæ, or sometimes the larvæ in their later stages as well as the pupæ, were subjected to artificial conditions in order to see whether any effect could be thereby produced on the following emergence. It is well known that very striking results have been brought about by artificial conditions of temperature in the case of dimorphic butterflies in Europe and North America. The names of Dorfmeister, W. H. Edwards, Weismann, Merrifield and Standfuss, to say nothing of others, will occur to every one as those of the authorities to whom we owe nearly

the whole of our knowledge in this particular. In view of the great difference between the temperate and tropical seasons, it was natural to suppose that the seasonal forms of tropical butterflies would be found to stand in relation to quite other meteorological conditions than those responded to by the Nearctic and Palæarctic species which had previously formed the subject of experiment. So far as I am aware, the only factor found generally operative in these latter cases is a raising or lowering of the temperature; the direct effect of humidity has been tried, but almost always with negative results. Mr. Marshall, on the other hand, has successfully used heat in combination with both moisture and dryness, and has also employed moisture unaccompanied by heat. By all these means, as will be seen, he has secured results analogous indeed with those of the European observers, but as a rule far less complete. It is possible that there may still be discovered some factor or combination of factors which will produce, in dimorphic tropical species, equally striking results with those to which Merrifield and Standfuss have now accustomed us. Most, however, of the species so far investigated by Mr. Marshall have proved comparatively resistent to this kind of treatment, and he has no instance of artificial modification which can be ranked with the *Araschnia levana* of many experimenters, or the *Selenia tetralunaria* of Mr. Merrifield.

Mr. Marshall's initials are here appended to each separate extract from his correspondence.

"*Estcourt, Natal; Dec.* 14, 1896.—I only succeeded in getting three eggs of *Teracolus topha*,* of which I send you one of the resulting specimens, which is undoubtedly *T. auxo*, being of the early wet-season form with the upper side black markings not yet fully developed. The eggs were laid within five minutes of one another, and they hatched simultaneously, but one larva pupated a day later than the other two and emerged a day later. The first two examples

* The result of this experiment was communicated by Mr. Marshall to the "Entomologist's Monthly Magazine," 1897, p. 52, and is referred to by Mr. Trimen in his address above quoted (Proc. Ent. Soc. Lond., 1898, p. lxxii). It should be noted that the name *T. topha*, Wallgrn., which is now used by both Mr. Marshall and Mr. Trimen to designate the dry-season form of *T. auxo*, is considered by Dr. Butler to be applicable rather to an intermediate form between *T. auxo* and *T. keiskamma*, Trim., the latter being the true dry-season phase. (Ann. Mag. Nat. Hist., 1897, ii, p. 453.)

(of which yours is one) are quite similar, but the third has the black edging to the apical patch of the forewing a trifle heavier, and also shows a trace of the black line along the inner edge of the patch characteristic of the full summer form. As the eggs were all laid by the same female, and the larvæ were reared under absolutely similar conditions, it would seem at first sight that the heavier markings could only be due to the longer larval stage, but this seems highly improbable. I was astonished at the rapid development of this species; egg-stage, three days; larval stage, twelve to thirteen days; pupal stage, eight days. Total, twenty-three to twenty-four days. From this I should estimate that there must be from nine to ten broods in the year."—G. A. K. M.

The above-mentioned specimen, a male, is now in the Hope collection, and entirely bears out Mr. Marshall's description. It is a well-marked, but not extreme example of the "wet-season" form *T. auxo*, Luc. Mr. J. Mansel Weale's experience of the same species is well known; * and it may be noted that of five bred examples sent to the Hope collection by Mr. Weale in 1878, there is a pair each of the *auxo* (wet) and *topha* (dry) form, together with a single female of an intermediate phase. Mr. Marshall's experiment removes the subject of the specific identity of these several forms from the region of probable conjecture to that of proof.

"*Estcourt, Dec.* 14, 1896.—While staying with Mr. Burn, at the junction of the Blaauwkraantz River with the Tugela, I tried to see whether the black markings of the early wet brood of *Teracolus annæ* could be intensified by damp surroundings, so as to resemble those of the full wet form. For this purpose I had a tin half filled with wet sand, in which I stuck the pupæ on thin sticks, covering it over with a cloth on which was a wet sponge. Into this I put five freshly-turned pupæ, of which I kept three in for seven days and two for nine. Only one specimen emerged out of each lot, and so far as I can see there is absolutely nothing unusual about either of them. Although the results of the experiment are negative, they are interesting, in that they *tend* to show that cold moisture cannot accentuate the black markings of the wet-season form, and also that cooler surroundings (induced by evapor-

* Trans. Ent. Soc. Lond., 1877, p. 273. See also Mr. Barker's comments; *Ibid.*, 1895, p. 422.

ation) do not tend to cause a reversion to the dry-season form. The first lot of *T. annæ* I bred (under ordinary conditions) were in pupa during fine warm weather, and took nine days to emerge. Those placed in the damp tin took in both cases twelve days. Three other pupæ kept under ordinary conditions were also twelve days in pupa, the last six days being cold, wet weather; these however were all of the full wet form, one female being even blacker than usual. With this species I observed that the bred specimens were nearly always more advanced in coloration than freshly emerged captured specimens."—G. A. K. M.

Eight of the specimens of *T. annæ*, Wallgrn. above referred to, are now in the Hope collection. One of these emerged on Nov. 17, 1896, after a pupal stage of twelve days, during seven of which it was kept in the damp tin jar, as above stated. It is an ordinary wet-season male, not extreme in character. A well-marked wet-season female, also in pupa twelve days, but under usual conditions, emerged on Nov. 11. This may be the female mentioned above. The only other bred specimen is a well-marked wet-season male, decidedly darker than the first. It emerged on Nov. 13, but there is no note as to its duration in the pupal state. The remaining five specimens were caught in the open. A female taken on Nov. 6 is wet-season; a pair on Nov. 12 are intermediate, as are two males taken on Nov. 14 and Nov. 16 respectively.

"*Estcourt, Dec.* 14, 1896.—On my return here I attempted a small test experiment as a converse of the former one, viz., submitting pupæ to dry warm conditions. My *modus operandi* was as follows: on a tripod stand I placed a round tin containing a little water; on the mouth of the tin was a china saucer filled with dried sand, in which were placed the pupæ beneath an inverted glass, the water being warmed by a spirit-lamp. Into this I put a suspended larva of *Byblia ilithyia*, a pupa seven days old, and another two days old. I applied too much heat at first, keeping the water at a boil, which killed the larva. I then turned the lamp as low as possible, keeping the tin just hot enough for the hand to bear. The older pupa emerged in three days (normal pupal stage, thirteen to fifteen days) and presents no marked peculiarity, as you may see, being of the early wet-season form, which was the only form occurring at that time in the natural state. The last

pupa emerged after six days' heating (eight days in pupa); unfortunately it had a difficulty in emerging, and I arrived too late to help it. But such as it is, it seems to me a very interesting specimen, for it is clearly intermediate in colouring, being therefore a step backwards towards the dry form. Its intermediate character is shown on the underside of hind wings, in the deeper ground-colour and more accentuated white bands, and on the upper side by the broad interruption about radial nervules of the submarginal black line in forewings, a character which only occurs in the dry or intermediate form of the female, and never in the early wet form of that sex."—G. A. K. M.

The two specimens here mentioned are both in the Hope collection. The difference between them is marked, the one which emerged on Nov. 27, from the pupa which was already seven days old before being exposed to dry warmth, being a wet-season male of the ordinary kind; while the other, which was only two days old when subjected to the same dry warmth, emerging on Nov. 30, is a crippled female, distinctly of the dry-season form, not extreme, but quite unmistakable, and entirely differing from specimens captured in the same locality at the same time of year.

"*Malvern, Natal; Feb.* 21, 1897.—I have been trying to find some reason to account for the occurrence of the marked varieties of *Biblia ilithyia*. This again is a widespread and common species, and comparatively conspicuous, so that there must be some sort of protective agency at work. I can only explain it by the fact that *B. ilithyia* strongly suggests an *Acræa* on the wing. Its general coloration, somewhat elongated wings and flapping flight (so different from that of its congeners), all tend to suggest this. That the typical form does not actually resemble any species of *Acræa* is of course plain, but I certainly regard the variety *acheloia* as a marked stage of incipient mimicry. On the underside, the hindwing of this variety, in its wet-season form, differs from that of the type in having lost the whitish bands, which gives it a very marked resemblance to *Acræa serena-buxtoni*. Again, the loss of the discal row of spots on the upper side of the hindwing points the same way, and it is interesting to note that, so far as my experience in South-east Africa goes, where *A. serena-buxtoni* occurs, there *acheloia* prevails over the typical form. Again, the chief difference between

the Central African *serena* and its southern sub-species is that in the former the black band near the apex of the forewing is continuous, but broken in the latter. If I remember right, there is a somewhat similar difference between *acheloia* and its Central African form *goetzius*, which, if correct, would further bear out my idea. Now as to the winter form; the underside of this is of course quite unlike that of any *Acræa*, and I can only suppose that it is a case of protective resemblance on the principle of the zebra's or tiger's stripes, for the insect always roosts on grass. It is interesting to note however that that part is undergoing modification in the variety *acheloia*, as the marginal white line in both wings has already done. It would be interesting to know whether there is any likeness between this species and the Indian *Acræas*."—G. A. K. M.

As I have elsewhere stated, I consider that *Byblia götzius*, Herbst, which Mr. Marshall here speaks of as *B. ilithyia* var. *acheloia*, is entitled to distinct specific rank beside *B. ilithyia*, Drury. Mr. Marshall's observation with regard to the continuity of the apical black band of the forewing in the Central African form of *B. götzius* is borne out on an examination of specimens in the Hope collection and the British Museum. It was remarked by me some time since, in discussing the modifications of *B. ilithyia* and its allies, that "the Socotran *B. boydi* resembles most specimens of *B. götzius* from the West African subregion in having the dark costal bar of the forewing continued rather heavily across the wing to join the submarginal band. This is also more or less the case with two females of *B. götzius* from Abyssinia, and specimens of the same from Somaliland and Aden in the British Museum; but in examples from South and East Africa the connection between the costal and the submarginal dark bands is often slight or absent." * It is worth noting that the marginal white line spoken of by Mr. Marshall, on the underside of both wings in the dry-season form of *B. ilithyia*, has disappeared from the dry-season *B. götzius*, but persists in *B. boydi*, of which only the dry-season form is at present known. This is another indication of the intermediate position of the latter insect, which, though nearer to *B. götzius*, yet shows several points of resemblance to *B. ilithyia*.

* Proc. Zool. Soc., 1898, p. 378.

On the whole Mr. Marshall's view as to the incipient mimicry of *Acræa serena*, Fabr., by *B. götzius* seems a very probable one. The underside of the wet-season *B. ilithyia* perhaps recalls slightly that of the Indian *Acræa* (*Telchinia*) *violæ*, Fabr., but the likeness in this case is of a remote kind.

"*Malvern, Natal; May* 14, 1897.—*Experiments on submitting pupæ to conditions of moisture or dry heat.* The apparatus used for dry-forcing was a covered tin (into which was poured a little water) placed on a tripod over a spirit-lamp. On the lid of the tin was placed some dried sand, into which was stuck a stick bearing the pupæ, which were covered with an inverted glass. The 'damp tin' contained very damp sand, the pupæ being separated from it by a grating of perforated zinc; and the mouth of the tin was covered with a cloth, on which was placed a wet sponge.

"Experiment with *Acræa cabira*.

1897

March 26. Two larvæ (*a* and *b*) pupated this morning; I put them in the dry forcer in the evening.

„ 28. A larvæ (*c*) pupated, and was left in the breeding-cage.

„ 31. Two larvæ (*d* and *e*) pupated; *d* put in the forcer, *e* left in breeding-cage.

April 6. *c* emerged, being a normal male.

„ 8. *e* emerged, a normal female; *d* not yet emerged, but still alive; *a* and *b* probably dead.

„ 9. *d* evidently too weak to emerge, so I helped it out, but it was only just alive, and wings did not expand. Its colouring was apparently normal. *a* and *b* never emerged at all, but shrivelled up.

"*Result.—Acræa cabira* apparently unable to exist in a very dry, hot climate, as might be supposed from its distribution. It is noteworthy that two pupæ of *Terias brigitta* emerged satisfactorily in forcer during the same period.

"Experiment with *Pinacopteryx pigea*.

1897

April 2. Seven larvæ (*a* to *g*) pupated.

1897

April 8. Put two pupæ (*a* and *b*) in dry forcer; two more (*c* and *d*) in damp tin; and left three (*e*, *f* and *g*) in breeding-cage.

„ 9. Took *c* and *d* out of damp tin, as they showed signs of emergence.

„ 10. *a*, *c* and *e* emerged in the morning. *a* was a female of the yellow form, showing an approach to the dry-season form in a slight reduction of all the black spots and borders, especially the discal spot in fore-wings; *c* was a female of the white form, and had all the black spots well marked; *e* was a white female, intermediate in the development of black markings between *a* and *c*.

Removed *b* from forcer to breeding-cage.

„ 11. *b*, *d*, *f* and *g* emerged. *b* was a white female in which the black markings were not quite so light as those of *a*, but noticeably lighter than those of *c*; *d* was a normal wet-season male; *f* and *g* were yellow females intermediate in markings between the extreme forms *a* and *c*.

"*Result.*—The differences exhibited are slight, but so far as they go they apparently tend to show that the effect of dry heat is to reduce the black markings, and that of cool moisture to enhance them. It is to be observed that yellow and white forms of the female occur at both seasons, the deeper yellow specimens are however more prevalent in winter. Reliable *seasonal* distinctions are greater or less development of the marginal black spots and discal spot in forewing, combined with less or greater acuteness of forewing.

"Experiment with *Crenis boisduvalii*.

1897

April 9. Twenty-two larvæ of *C. boisduvalii* pupated.

„ 10. Put six pupæ into dry forcer; six into damp tin; and left the rest in breeding-cage.

„ 14. Six pupæ in forcer emerged; there were four male and two female, but two of the former were deformed.

1897.

April 15. Three males and three females emerged in damp tin; one male escaped and another was deformed. Three males and six females also emerged in breeding-cage.

"On comparing the three sets of specimens the differences were found to be remarkably slight, all the specimens being of a more or less intermediate character between the wet and dry season forms (as might be expected during this month for those bred under normal conditions). But such slight differences as do exist appear to be fairly constant. In the females the black patches on the underside of the forewings are constantly best developed in those from the damp tin and least in those from the forcer. Those reared under normal conditions are much nearer the former in this respect, being all rather lighter, except examples which are hardly separable from those reared under moist conditions. The differences in the hindwings are too slight to be taken into account. In the males those from the forcer show a slight difference from the rest in having the black mark on the underside of the forewing somewhat reduced, and a greater suffusion of ochreous scales on the upper side of the hindwing. The others are practically inseparable. The seasonal differences in this species are very clearly defined as a rule.

"Second Experiment with *Pinacopteryx pigea*.

1897.

April 8. Six larvæ pupated (*a* to *f*).
„ 9. Two larvæ pupated (*g* and *h*). Put *a*, *b* and *c* into dry forcer, and *d* and *e* into damp tin.
„ 10. Two larvæ (*j* and *k*) pupated. Put *g* into damp tin.
„ 15. Removed *a* and *b* from forcer to breeding-cage; *c* was dead; cause unknown.
„ 16. *a* and *b* emerged; both females.
„ 17. *f* and *h* emerged in breeding-cage; both females.
„ „ *d* emerged in damp tin; female.
„ 18. *e* emerged in damp tin; female.
„ „ *j* emerged in breeding-cage; female.
„ 19. *g* and *k* emerged in damp tin and breeding-cage respectively; both males.

"No notes were kept of individual markings, but on comparing the three sets it was noticeable, as in previous experiments, that considering the disparity of conditions, the markings showed wonderfully little difference. It is however indisputable that, taking the specimens in conjunction with those of the previous experiment, all those subjected to dry heat had the black markings appreciably less developed than those whose pupæ were kept in a cool, moist atmosphere. Those that were reared entirely in the breeding-cage are mostly of an intermediate type of colouring, though two are quite as bright as the heated specimens, but none of them resemble those that were kept damp.

"It is noteworthy that in *Crenis boisduvalii* the specimens reared under normal conditions showed just the opposite tendency.

"Although the experiments are on far too small a scale to *prove* anything one way or the other, yet to my mind they appear to lend more support to the theory that the heavier development of black markings in South African butterflies during the summer is probably more dependent on the prevalence of moisture than on the action of heat: though the very small effects shown by these agents in the above experiments suggest the supposition that the absence or presence of black markings alone cannot be referred entirely to climatic agency, as I had been previously inclined to think, but have been developed by natural selection, for some purpose not at present apparent, which has worked on the slight tendency to variation caused by climatic influence."—G. A. K. M.

In 1896 Mr. Marshall had exposed some larvæ of *Acræa anacreon* to "dry-season" conditions just before pupation, but they all died in consequence, as he believes, of overheating (Estcourt, Oct. 15, 1896). On Oct. 7, 1897, he writes from Malvern: "The experiment in which I found that the pupæ of *Acræa cabira* were killed by dry heat which did not affect *Terias brigitta*, leads me to think some of these highly-developed nauseous species may have suffered in hardness of constitution, which would account for their not spreading more widely than they do."

Of the specimens referred to by Mr. Marshall in the two series of experiments on *Pinacopteryx pigea*, Boisd., *a*, *c* and *e* of the first series, and *a*, *b*, *d*, *e*, *f* and *h* of the second series are in the Hope collection. The divergences noted

as the result of the different treatment are more easily visible in the first series than in the second.

The Hope collection also possesses seven specimens of the above-mentioned series of *Crenis boisduvalii*, Wallgrn. These are a pair of the "dry heat" emergence on April 14; a pair of the "damp tin" emergence on April 15; and a male and two females which emerged under normal conditions, also on April 15. There is no doubt that the "dry heat" female is considerably lighter on the upper surface, and has the dark marks on the under surface of the forewings less distinctly marked than any of the others. The differences between the males are of the same kind, but somewhat less apparent.

"Aug. 29, 1899.—I am sending you by this mail a small lot of butterflies, including the bred *P. sesamus* and *archesia*, and twenty-one bred specimens of *Teracolus omphale* and *T. achine*, with their respective parents. . . . The *Teracoli* will be valuable as actually proving seasonal dimorphism in these species. I must admit that I was much surprised to find that the warm, damp atmosphere had no effect on *T. omphale* (D1—4) whatever.* The apparatus I used was a very deep circular tin (uncovered), which was partially filled with water, in which was placed a stand; to this the pupæ were pinned, they being about four inches above the water. In the case of *T. omphale* (D1—4) I kept the spirit-lamp with only a tiny flame, so as to keep the water just hot, and so that a faint warmth could always be felt on placing the hand above the mouth of the containing tin. On account of the negative results thus obtained, I came to the conclusion that the heat applied was perhaps insufficient in all these cases. Unfortunately, I had not enough material left to test this properly, but in the case of *T. achine* (C1 and C2) I kept the water at about 180° F., still keeping the tin uncovered, and, as you will see, this has undoubtedly had a more decided effect, especially in the case of C2, which was put in before actual pupation. I was, however, surprised that with C1 the protectively coloured under side should have been affected, rather than the black markings of the upper side. In view of this result I think the previous experiments must not be taken as conclusive. Among the *Teracoli* there

* It appears to me to have had a slight effect, as can be seen on comparing D2, D3 and D4 with D5, D6 and D7. See pp. 211–13.—F. A. D.

is a highly interesting female *omphale* (E, No. 15)."—G. A. K. M.

The specimens of *Teracolus* here spoken of were all obtained at Salisbury, Mashonaland. They are as follows:—

1. *Teracolus achine*, Cram.

X. A "wet-season" female (Figs. 5, 5*a*). Captured March 26, 1899. Laid one egg.

X1. Offspring of X. From egg laid March 26; hatched March 31; pupated April 23; kept under normal conditions; emerged May 9. A "dry-season" female, not extreme, corresponding to the form described by Trimen (South African Butterflies, vol. iii, 1899, p. 136) as *T. antevippe*, Boisd., ♀. (Figs. 6, 6*a*.)

B. An "intermediate" female. Captured April 23, 1899; laid 15 eggs.

B1. Offspring of B. Egg laid April 23; hatched April 29; pupated June 12; kept under normal conditions; emerged July 20. A dry-season male, corresponding to *T. antevippe*, Boisd., as described by Trimen, *loc. cit.*

B2. Offspring of B. Egg laid April 23; hatched April 29; pupated June 15; kept under normal conditions; emerged July 22. A well-marked dry-season male, the pink of the hindwing under side more pronounced than in B1. The left hindwing is not completely expanded.

C. An intermediate female, verging towards "dry." Captured April 26, 1899; laid 17 eggs.

C1. Offspring of C. Egg laid April 26; hatched May 3; exposed to damp heat from 10 p.m., June 22, to 8 a.m., July 4. Emerged July 7. An intermediate male, on the under side resembling the wet-season form.

C2. Offspring of C. Egg laid April 26; hatched May 3; exposed to damp heat from 10 p.m., June 22, to 8 a.m., July 4; pupated 8 a.m., June 23; emerged July 8. An intermediate male, like C1, but somewhat more closely approaching the wet-season form on the upper surface.

C3. Offspring of C. Egg laid April 26; hatched May 3; pupated June 22; kept under normal conditions; emerged July 29. A male, intermediate on the

upper surface, but with the under side decidedly of the dry-season type.

C4. Offspring of C. Egg laid April 26; hatched May 3; pupated June 28; kept under normal conditions; emerged Aug. 3. A dry-season female.

2. *Teracolus omphale*, Godt.

D. A wet-season female (Figs. 7, 7*a*). Captured April 26, 1899. On the same day laid 19 eggs, which hatched on May 3. Seven of the resulting butterflies are in the Hope collection, as follows :—

D1. Exposed to damp heat from 6 p.m., June 17, to 11 p.m., June 25; pupated 11 p.m., June 17; emerged June 27. A dry-season male, crippled.

D2. Pupated 2 p.m., June 17; damp heat 6 p.m., June 17, to 11 p.m., June 25; emerged June 27. A yellow dry-season female, imperfectly expanded.

D3. Damp heat 6 p.m., June 17, till emergence; pupated 8 p.m., June 17; emerged June 28. A yellow dry-season female.

D4. Pupated 2 p.m., June 17; damp heat 6 p.m., June 17, to 11 p.m., June 25; emerged June 29. A dry-season male, not extreme.

D5. Pupated June 10; normal conditions; emerged July 12. A white dry-season female, more advanced than D2 and D3; as shown by the diminution of the dark markings on the upper surface, and the disappearance of the transverse bar and orange-shaded discoidal spot on the under side of the hindwing, traces of these being visible in both the females D2 and D3, which had been exposed as pupæ to damp heat.

D6. Pupated June 10; normal conditions; emerged July 14 (Figs. 8, 8*a*). A white dry-season female, still more advanced than D5.

D7. Pupated June 16; normal conditions; emerged July 17. A dry-season male, more advanced than D4.

E. A yellowish wet-season female. Captured April 30, 1899. Laid 15 eggs the same day. Offspring :—

E1. Hatched May 8; pupated June 28; normal conditions; emerged July 25. A white dry-season female, with dark markings on disc of forewing greatly reduced, and with a yellowish shade re-

placing the orange in the centres of the apical interspaces. This is the specimen referred to by Mr. Marshall as E, No. 15 (p. 210).

E2 and 3. Hatched May 8; pupated June 28; normal conditions; emerged July 26. Two dry-season males.

F. A wet-season female. Captured May 3, 1899. Laid 2 eggs, which hatched on May 9. Offspring:—

F1. Pupated June 27; normal conditions; emerged July 26. A dry-season male.

F2. Pupated June 28; normal conditions; emerged July 26. A yellow dry-season female, not extreme.

G. A wet-season female. Captured May 10, 1899. Laid 10 eggs. Offspring:—

G1. Hatched May 18; reared under normal conditions; emerged July 31. A white dry-season female, not extreme.

G2. Hatched May 18; normal conditions; emerged Aug. 3. A dry-season male.

In all the above cases, the "dry-season" offspring of the parent *Teracolus omphale* corresponds generally with the form described by Mr. Trimen (South African Butterflies, vol. iii, 1889, p. 145) as *T. theogone*, Boisd. The specific identity of these two forms had long been suspected, and by the above series of specimens is placed absolutely beyond doubt.

In 1898 Mr. Marshall sent home a collection of butterflies from Salisbury, Mashonaland, which was described by Dr. Butler in Proc. Zool. Soc., 1898, pp. 902–912. In an accompanying letter to Dr. Butler he says: "I am somewhat in doubt as to the *Teracoli* I have sent you labelled *pallene*, for they are practically indistinguishable from the extreme dry form of *omphale*; yet the wet form is certainly not *omphale*, which I do not remember ever to have seen here, but seems referable to *pallene*." Dr. Butler (*loc. cit.*, p. 911) "has not the least doubt that these examples are ordinary *T. omphale*." An examination of similar specimens sent to the Hope collection by Mr. Marshall as *T. pallene*, led me independently to the same conclusion as Dr. Butler; and it is worthy of notice that while several of the bred examples just described are not separable from Mr. Marshall's specimens of *T. pallene*, the four parents, all of which were captured at Salisbury, are identified by Mr. Marshall himself as *T. omphale*. The inference seems

clear that there is no reason for considering Mr. Marshall's "*T. pallene*" from Mashonaland as specifically different from *T. omphale*.

It will be seen from the above descriptions that the damp heat to which many of the specimens of *T. omphale* were exposed was not entirely without effect; though the changes in the direction of the wet-season form are no doubt less marked than those produced in the case of *T. achine*, where the heat employed was greater.

3. *Teracolus phlegyas*, Butl.* (*T. difficilis*, E. M. Sharpe).

One specimen: Salisbury, Mashonaland. Larva suspended June 6, 1898; placed in damp forcer June 7; pupated same day; removed June 30; emerged June 31. An intermediate female, on the whole nearer to the dry than to the wet-season form. The dark markings on the upper surface of the forewings, including the discoidal spot, are, however, somewhat strongly developed for a dry-season form; and there is a well-defined grey basal patch, but no dark inner-marginal bar. Beneath, the hindwings have lost the definite spots of the wet-season phase, but have not assumed the dry-season colouring in its full development.

This completes the list of specimens of *Teracolus* mentioned by Mr. Marshall in his letters. The succeeding extracts bear reference to the African forms of the genus *Byblia*, Hübn.

"April 25, 1899.—I have a few authentic eggs of *Byblia ilithyia* and *acheloia*, which may perhaps decide the justice of Dixey's contention as to the specific validity of the latter.

"April 19, 1901.—I hope to be able to get some definite evidence as to *Byblia*, as I have now five pupæ and three larvæ bred from authenticated eggs of *ilithyia*, and one pupa and six larvæ from those of *vulgaris*, *i. e.* the wet-season form of *B. acheloia* (=*B. götzius*). The resulting butterflies will also prove the seasonal variation in the two forms. So far as my present material goes, I find that there is a very slight colour-distinction between the two larvæ in the last stage only.

"Sept. 27, 1901.—The specimens resulting from my damp experiments, together with those already sent, might

* This, though belonging to an earlier series of experiments, is inserted here for convenience

form the nucleus of a most interesting and instructive series to show the experimental evidence as to the proximate causes of seasonal dimorphism. . . . . You will find some of the specimens from my *Byblia* experiments. The few that emerged all bred true to their parents, but the principal evidence consists in a slight, though constant, colour-distinction which I found in the larvæ of the two insects, thus proving them to be distinct species."—G. A. K. M.

It is satisfactory to me to find that in consequence of his latest experiments, Mr. Marshall now holds the view as to the specific distinction between the two continental forms of *Byblia* which I felt justified in putting forward in 1898.* The specimens recently forwarded by him to the Hope collection from Salisbury, Mashonaland, are as follows:—

A. *B. ilithyia*, Drury. A worn wet-season female. Captured March 17, 1901. Laid 3 eggs. Offspring:—

A1. Hatched March 21; pupated April 11; emerged April 28. A wet-season female.

A2. Hatched March 21; pupated April 11; emerged April 29. An intermediate male.

B. *B. ilithyia*, Drury. A worn wet-season female (Fig. 1). Captured March 17, 1901. Laid 5 eggs. Offspring:—

B1. Egg laid March 24; hatched March 28; pupated April 11; emerged April 29. An intermediate male.

B2. Egg laid March 24; hatched March 28; pupated April 11; emerged April 30. An intermediate female (Fig. 2).

B3. Egg laid March 24; hatched March 28; pupated April 11; emerged May 1. An intermediate male.

C. *B. götzius*, Herbst. A worn wet-season female, of the form *vulgaris*, Staud. (Fig. 3). Captured March 24, 1901. Laid 6 eggs. Offspring:—

C1. Egg, March 24; hatched March 28; pupated April

* Proc. Zool. Soc., 1898, p. 376. The current number (Feb. 1902) of the "Entomologist's Monthly Magazine" contains the first instalment of a paper by Mr. Marshall in which he gives a detailed account of his experiments in the breeding of *Byblia ilithyia* and *B. götzius*, with descriptions of larvæ and pupæ.

22; emerged May 8. A dry-season male, of the form *achcloia*, Wallgrn. (Fig. 4).

C2. Egg, March 24; hatched March 28; pupated April 24; emerged May 13. A dry-season male, like C1.

E. *B. ilithyia*, Drury. A wet-season female. Captured March 24, 1901. Laid 2 eggs. Offspring:—

E1. Egg, March 24; hatched March 28; pupated April 27; emerged May 19. An intermediate male.

These specimens supply complete proof, if proof were wanted, of the specific identity of *B. vulgaris*, Staud. with *B. achcloia*, Wallgrn., and also of *B. ilithyia*, Drury, with the African form corresponding to *B. simplex*, Butl., of India. It is to be noted that none of the bred *B. ilithyia* are of the full dry-season form. One or two of them, however, approach it so closely as to leave no manner of doubt that later in the year the typical "dry-season" colouring would be developed.

The following specimens of *Terias* sent home by Mr. Marshall are also worthy of note:—

Terias brigitta, Cram.

A. Malvern, Natal. Pupa in dry heat 6 days; emerged April 4, 1897. A wet-season male.

This is no doubt one of the two *T. brigitta* mentioned above (p. 205) as having withstood an amount of heat which proved fatal to *Acræa cabira*.

B. Malvern, Natal. Pupa under normal conditions; emerged April 9, 1897. A wet-season female.

Terias senegalensis, Boisd.

A. Salisbury, Mashonaland. Captured April 7, 1901. (Figs. 9, 9*a*.) Laid 3 eggs. A wet-season female of *T. senegalensis*, Boisd. Offspring:—

A1. Egg laid April 7; hatched April 11; emerged June 10. (Figs. 10, 10*a*.) A dry-season male, of the form *T. æthiopica*, Trimen.

These two specimens are of great interest, as showing that a *T. hapale*-like form (*T. æthiopica*) may be bred from a *T. hecabe*-like parent (*T. senegalensis*); and as thus tending in some respects to confirm Mr. Marshall's view expressed to Dr. Butler in 1898 as follows:—

"You will notice among the *Terias* that I have pointed

out that *T. æthiopica* and *butleri* of Trimen are respectively dry and wet forms of the same species, and thus, taking the synonymy given in your revision, *hapale* must fall as a seasonal form of *senegalensis*. I have not actually proved the case by breeding, but I think you can take my observations on trust now."* I may mention that I had some time ago come independently to the conclusion that the *T. hapale* forms could not be specifically separated from the *T. senegalensis* assemblage, and had arranged the examples in the Hope collection in accordance with that view. But I do not think that even now the seasonal relations of these forms are quite clear.

In addition to the series just described, Mr. Marshall has also presented to the Hope collection the greater number of the specimens resulting from the experiments recorded by him in the "Annals and Magazine of Natural History," 1901, vol. ii, p. 398. They exemplify the very slight effect produced on the early dry-season broods by subjecting the larvæ and pupæ to conditions of moisture without heat. In Mr. Marshall's opinion, the amount of occasional inclination towards the wet-season form shown in this series is no more than might have been met with in examples of similar dates caught in the open. These specimens need no further notice here, having been fully dealt with by Mr. Marshall in his paper above referred to.

5. Summary.

The main points of the present paper may be summarized as follows:—

1. *Catopsilia pomona*, Fabr. (including *C. catilla*, Cram.), and *C. crocale*, Cram. are phases of a single species. In at least one part of its range, these phases appear to be in relation with the seasons; in other parts there seems to be no such connection.

2. In like manner *Catopsilia pyranthe*, Linn. is conspecific with *C. gnoma*, Fabr. Here the association of each form with its own season is better recognized, but there is reason to think that even in this case the relation by no means obtains universally.

3. There are many other instances on record of the simultaneous occurrence in a given locality of forms of a

* Proc. Zool. Soc., 1898, p. 909.

species which are either known to be characteristic of the seasons in other parts of the range of the species, or which at least are analogous with proved cases of seasonal dimorphism.

4. Some of these cases of simultaneous occurrence are undoubtedly due to an overlapping at the change of seasons. In other instances the intermingling of the different forms takes place indifferently all the year round. This is perhaps more especially apt to occur in regions where the climate does not show very well-marked alternations between wet and dry.

5. Mr. Marshall has proved the specific identity of the following pairs of forms by actually breeding one from the other:—(*a*) *Teracolus topha*, Wallgr., and *T. auxo*, Luc.; (*b*) *Teracolus achine*, Cram., and *T. antevippe*, Boisd.; (*c*) *Teracolus omphale*, Godt., and *T. theogone*, Boisd.; (*d*) *Terias senegalensis*, Boisd., and *T. æthiopica*, Trim.; (*e*) *Byblia götzius*, Herbst (*vulgaris*, Staud.), and *B. acheloia*, Wallgrn.; (*f*) *Byblia ilithyia*, Drury, and the African form of *B. simplex*, Butl. In each of these cases it was already known that the different forms were respectively associated with different seasons, but the actual proof of specific identity afforded by "breeding through" had hitherto been wanting.

6. The final stage can in many cases be influenced by the artificial application of heat or moisture during the pupal condition. Thus, Mr. Marshall has found that dry warmth may cause the early wet-season form of *Byblia ilithyia* to approach the dry-season type of coloration; while the intermediate or early dry-season forms of *Pinacopteryx pigea* and *Crenis boisduvalii* were slightly affected in the same direction. Warmth in conjunction with moisture produced in early dry-season forms a tendency to revert to the garb of the rains. This was well seen in *Teracolus achine*, and to a less extent in *T. phlegyas* and *T. omphale*. On the other hand, neither the early wet-season form of *T. annæ* (1896), nor the early dry-season forms of several other species (1901) seem to have been affected by the application of moisture without the addition of heat, though a tendency towards the wet-season form made itself apparent under these conditions in *Pinacopteryx pigea* and, to a slighter extent, in *Crenis boisduvalii*.

7. Mr. Marshall has now detected constant differences in the respective larvæ and pupæ, which prove that *Byblia*

götzius (including *B. vulgaris*) is specifically distinct from *B. ilithyia*.

In conclusion, I wish to thank the authorities of the British Museum of Natural History, particularly Dr. Butler and Mr. Heron, for help that has always been courteously and readily given. My obligations to Professor Poulton are still more weighty; I owe to him the enjoyment of complete facilities for work in the Hope Department at Oxford, the loan of Mr. Marshall's letters, and the photographs of specimens that illustrate this paper. With regard to Mr. Marshall himself, I should wish to place on record my sense of the high value of his work as collector, experimenter and observer. He has had good opportunities, which he has known how to use in a thoroughly scientific manner. Moreover, what he has already achieved justifies us in looking for still greater results from his persevering labours.

Explanation of Plate IV.

Fig. 1 (underside). *Byblia ilithyia*, Drury. A wet-season female.
2 (underside). Offspring of the above. An intermediate female, approaching the "dry" form which corresponds to the Indian *B. simplex*, Butl.
3 (underside). *Byblia götzius*, Herbst. A wet-season female, of the form *vulgaris*, Staud.
4 (underside). Offspring of the above. A dry-season male, of the form *acheloia*, Wallgrn.

(See pages 214, 215.)

5, 5*a* (underside). *Teracolus achine*, Cram. A wet-season female.
6, 6*a* (underside). Offspring of the above. A dry-season female of the form described by Trimen as *antevippe*, Boisd.
7, 7*a* (underside). *Teracolus omphale*, Godt. A wet-season female.
8, 8*a* (underside). Offspring of the above. A dry-season female, of the form described by Trimen as *theogone*, Boisd.

(See pages 210–211.)

9, 9*a* (underside). *Terias senegalensis*, Boisd. A wet-season female.
10, 10*a* (underside). Offspring of the above. A dry-season male, of the form *æthiopica*, Trimen.

(See page 215.)

In the actual specimens, owing to the presence of colour, the difference between the wet- and dry-season forms of the same species is more striking than appears in the Plate.